IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PDT PHY COBF | | | | |
| Date: 2024-12-16 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Ron Porat | Broadcom Inc |  |  | ron.porat@broadcom.com |
| Sameer Vermani | Qualcomm |  |  | svverman@qti.qualcomm.com |
| You-Wei Chen | MediaTek |  |  | you-wei.chen@mediatek.com |
| Alice Chen | Qualcomm |  |  |  |
| Srinath Puducheri | Broadcom |  |  |  |
| Juan Fang | Intel |  |  |  |
| Karim Toussi | Broadcom |  |  |  |
| Jianhan Liu | MediaTek |  |  |  |
| Qinghua Li | Intel |  |  |  |
| Hari Ram Balakrishnan | NXP |  |  |  |
| Tianyu Wu | Apple |  |  |  |
| Wook bong Lee | Apple |  |  |  |
| Mengshi Hu | Huawei |  |  |  |
| Aniruddh Rao | Samsung |  |  |  |
| Bin Tian | Qualcomm |  |  |  |
| Aiguo Yan | Samsung |  |  |  |
| Shimi Shilo | Huawei |  |  |  |
| Junghoon Suh | Huawei |  |  |  |
| Jason Yuchen Guo | Huawei |  |  |  |
| Youhan Kim | Qualcomm |  |  |  |
| Sigurd Schelstraete | Maxlinear |  |  |  |
| Yeon-Geun Lim | Newracom |  |  |  |
| Leonardo Lanante | Offino |  |  |  |
| Insik Jung | LGE |  |  |  |
| Qinglai Liu | Panasonic |  |  |  |
| Xiaogang Chen | Spreadtrum |  |  |  |
| Jay Yang | ZTE |  |  |  |
| Kosuke Aio | Sony |  |  |  |
| Rui Cao | NXP |  |  |  |

Abstract

This document contains Proposed Draft Text (PDT) for PHY aspects of the COBF feature of the proposed TGbn (UHR, Ultra High Reliability) amendment to the 802.11 standard and is limited to sections 38.x.

# Revision information

The following is a summary of the important changes that occurred within each revision of this document:

|  |  |
| --- | --- |
| **Revision** | **Major changes** |
| 0 | Initial revision |
| 1 | Resolve comments from Wook bong, Qinglai, Leonardo, Xiaogang, Jay |
| 2 | Resolve comments from Leonardo, Qinglai, Insik, Kosuke |
| 3 | Resolve comments from Rui Cao |
|  |  |
|  |  |

# Introduction

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGbn Draft. The abstract, revision information, introduction, explanation of the proposed changes, and references sections are not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGbn Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

## Explanation of the proposed changes:

The proposed changes to the 802.11 TGbn draft within this document are based on the following motions adopted by the TGbn task group.

### Relevant passing PHY motions in doc 24/0171 [1]:

[Motion #9, [1]]

Move to add the following text to the TGbn SFD:

•      Define a multi-AP Coordinated Spatial Reuse at TxOP-level with power control

•      Define multi-AP Coordinated Beamforming

•      Other multi-AP coordination modes are TBD

[Motion #99, [1]]

* The Coordinated beamforming (COBF) transmission phase in 802.11bn shall be limited to 2 APs.

[Motion #111, [1]]

Move to add to the TGbn SFD the following:

The pre-UHR portion (the portion up-to and including UHR-SIG) of the COBF PPDU shall be transmitted in a non-beamformed (omni) manner.

[Motion #112, [1]]

Move to add to the TGbn SFD the following:

* The pre-UHR portion of a COBF PPDU shall have identical content across two APs.

[Motion #114, [1]]

Move to add to the TGbn SFD the following:

* In a COBF transmission, the maximum number of spatial streams given to one user will be 2.

# Text to be adopted begins here:

***TGbn editor: Please add the following new subclauses for COBF to the 802.11bn draft D0.1:***

#### **38.1 Introduction**

#### **38.1.1 Introduction to the UHR PHY**

A UHR AP may support the following features:

* Full bandwidth and partial bandwidth UHR sounding as defined in 37.6.2 (UHR sounding protocol).

A non-AP UHR STA shall support the following features:

* Responding with requested beamforming feedback in a UHR sounding procedure with up to 4 spatial streams in the EHT sounding NDP if the non-AP STA supports COBF, except for a 20 MHz-only non-AP STA with 20 MHz-Only Limited Capabilities Support subfield equal to 1.
* Full bandwidth UHR sounding as defined in 37.6.2 (UHR sounding protocol) if the non-AP STA supports COBF.

# 38.3.14 UHR preamble

## 38.3.14.1 Introduction

The UHR preamble consists of pre-UHR modulated fields and UHR modulated fields. The pre-UHR modulated fields for the three UHR PPDU formats are the following:

— L-STF, L-LTF, L-SIG, RL-SIG, and U-SIG fields of a UHR TB PPDU

— L-STF, L-LTF, L-SIG, RL-SIG, U-SIG, and UHR-SIG fields of a UHR MU PPDU

— L-STF, L-LTF, L-SIG, RL-SIG, U-SIG, and ELR-MARK fields of a UHR ELR PPDU

The UHR modulated fields in the preamble for the UHR TB PPDU and UHR MU PPDU formats are the UHR-STF and UHR-LTF fields.

For a UHR MU PPDU using COBF, the pre-UHR modulated fields are non-beamformed and the UHR modulated fields including the UHR-STF and UHR-LTF fields are beamformed as the Data field.

For a UHR MU PPDU using COBF, the pre-UHR modulated fields shall have identical content across all participating APs and shall be transmitted by all participating APs.

38.3.20 Coordinated Beamforming

38.3.20.1 Introduction

Coordinated Beamforming (COBF) is a technique used by multiple APs each with multiple antennas (each of the APs acting as a beamformer) to steer signals using knowledge of the channel to improve throughput, reliability and to reduce latency. With SU-MIMO beamforming all spatial streams in the transmitted signal are intended for reception at a single STA. With DL MU-MIMO beamforming, disjoint subsets of the spatial streams are transmitted from a single AP and are intended for reception at different non-AP STAs. With COBF, disjoint subsets of spatial streams are transmitted from different APs, where each AP’s subset of streams may be further divided into the streams intended for reception at multiple non-AP STAs associated with that AP.

Depending on the channel knowledge available and the antennas available at the APs, the steering matrices used by all the APs may ensure a minimal signal strength of an AP’s spatial streams at either all the antennas of all the other AP’s recipients or over a subspace of the eigen-modes of the channels to the other AP’s recipients (if those recipients contain more than one antenna).

The sounding procedure needed for obtaining the channel knowledge for performing this steering for COBF is described in 37.6 UHR sounding operation.

For COBF, the receive signal vector in subcarrier *k* at beamformee *u*, , is shown in Equation (21-101), where  denotes the transmit signal vector in subcarrier *k* for all *Nuser* beamformees, with being the transmit signal for beamformee *u*.



where

***H****k,u* is the compound channel matrix from the beamformers to beamformee *u* in subcarrier *k* with dimensions , where NTX is the total number of transmit chains across all the participant beamformers

 is the number of receive chains at beamformee *u*

 is a steering matrix for beamformee *u* in subcarrier *k* with dimensions x and it has zero entries for the rows corresponding to antennas of APs that the beamformee *u* is not associated with.

*Nuser* is the number of COBF PPDU recipients (see Table 21-6 (Frequently used parameters))

***n*** is a vector of additive noise and may include interference

The COBF steering matrix  has sections (disjoint sets of rows) which are calculated by different beamformers using the beamforming feedback matrices *Vk,u* for subcarrier *k* from beamformee *u*, and SNR information *SNRk,u* for subcarrier *k* from beamformee *u*, where . Note, that all the APs participating in a COBF transmission need to have the channel state information to all the recipients to make this calculation possible. The process for getting this information is described in 37.6 UHR sounding operation.

38.3.20.2 Beamforming Feedback Matrix *V* during UHR sounding operation

Upon receipt of a EHT sounding NDP as part of a UHR TB sounding sequence, the beamformee shall follow the procedure as described in 27.3.16.2 (Beamforming feedback matrix V), to calculate the compressed beamforming feedback matrix in the form of angles which are sent to the beamformers in the CSI feedback*,* with an additionalrestriction specific to COBF that the feedback type shall be fixed to MU type feedback. The beamformee shall generate the beamforming feedback matrices with the number of rows (*Nr*) equal to the *NSTS* of the NDP. CSD removal guidelines, quantization requirements, tone-grouping options and codebook sizes shall also stay the same as described in section 27.3.16.2.

After receiving the angle information, the beamformers reconstructs *Vk,u* using Equation (19-79). For COBF, the participating beamformers may calculate a portion of the overall steering matrix  using *Vk,u* and *SNRk,u* () in order to suppress crosstalk between participating beamformees. The method used by the beamformers to calculate the portions of the steering matrix *Qk* is implementation specific.

In UHR sounding, the transmitter of the UHR NDP Announcement frame decides the tone grouping and codebook size to be used in the beamforming feedback matrix *V* (regardless of which AP in sending the NDP).

38.3.20.3 Supported RU sizes in COBF

COBF transmissions in UHR is applicable only to non-OFDMA DL transmissions

38.3.20.4 Number of APs, STAs and spatial streams in a COBF PPDU

The number of participating APs in a UHR COBF transmission shall be 2. The total number of recipient STAs across the 2 APs in a COBF transmission shall be less than or equal to 4. The maximum number of spatial streams per user in COBF is 2.

COBF transmissions are defined only for a UHR AP that can transmit 4 or more spatial streams.

The maximum total number of spatial streams in a COBF PPDU across all recipients shall be 4.

#### **38.3.21 EHT sounding NDP for UHR TB sounding sequence**

The EHT sounding NDP is a variant of the EHT MU PPDU as defined in 36.3.18 (EHT sounding NDP). An EHT sounding NDP for UHR TB sounding sequence is indicated by setting the PHY Version Identifier to 0 (EHT), PPDU Type And Compression Mode field to 1, the EHT-SIG MCS field to 0, and the Number Of EHT-SIG Symbols field to 0 in the U-SIG field. The format of an EHT sounding NDP for UHR TB sounding sequence is illustrated in Figure 38-x (EHT sounding NDP format for UHR TB sounding sequence).



#### **Figure 38-x—EHT sounding NDP format for UHR TB sounding sequences**

The BSS Color in the U-SIG of the EHT sounding NDP for UHR TB sounding is set to the BSS Color subfield carried in the STA info field of the most recent UHR NDP Announcement frame (see 9.3.1.19.6 (UHR NDP Announcement frame format)).

The number of EHT-LTF Symbols is set to four or eight. Other values are disallowed.

In sounding NDP used for COBF, the number of spatial streams is set to four or eight spatial streams.

GI+LTF size is set to either 2 EHT-LTF with 0.8 µs GI or 2 EHT-LTF with 1.6 µs GI. The other combinations of EHT-LTF type and GI duration are disallowed.